(c) At least weekly or after any maintenance which could alter calibration, the following checks shall be performed:

(1) Perform a CVS system verification.

(2) Check the shaft torque feedback signal at steady-state conditions by comparing:

(i) Shaft torque feedback to dynamometer beam load; or

(ii) By comparing in-line torque to armature current; or

(iii) By checking the in-line torque meter with a dead weight per § 86.1308(e).

(d) The CVS positive displacement pump or critical flow venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.1319).

(e) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

(f) For diesel fuel testing only. The carbon monoxide analyzer shall be calibrated at least every two months or after any maintenance which could alter calibration.

[59 FR 48530, Sept. 21, 1994, as amended at 60 FR 34371, June 30, 1995; 62 FR 47126, Sept. 5, 1997]

§ 86.1318–84 Engine dynamometer system calibrations.

(a) The engine flywheel torque and engine speed measurement transducers shall be calibrated at least once each month with the calibration equipment described in § 86.1308–84.

(b) The engine flywheel torque feedback signals to the cycle verification equipment shall be electronically checked before each test, and adjusted as necessary.

(c) Other engine dynamometer system calibrations shall be performed as dictated by good engineering practice.

(d) When calibrating the engine flywheel torque transducer, any lever arm used to convert a weight or a force through a distance into a torque shall be used in a horizontal position (±5 degrees).

(e) Calibrated resistors may not be used for engine flywheel torque transducer calibration, but may be used to span the transducer prior to engine testing.

§ 86.1319–84 CVS calibration.

(a) The CVS is calibrated using an accurate flowmeter and restrictor valve. The flowmeter calibration shall be traceable to the NBS, and will serve as the reference value (NBS "true" value) for the CVS calibration. (Note: In no case should an upstream screen or other restriction which can affect the flow be used ahead of the flowmeter unless calibrated throughout the flow range with such a device.) The CVS calibration procedures are designed for use of a "metering venturi" type flowmeter. Large radius or ASME flow nozzles are considered equivalent if traceable to NBS measurements. Other measurement systems may be used if shown to be equivalent under the test conditions in this action and traceable to NBS measurements. Measurements of the various flowmeter parameters are recorded and related to flow through the CVS. Procedures used by EPA for both PDP– and CFV–CVS's are outlined below. Other procedures yielding equivalent results may be used if approved in advance by the Administrator.

(b) After the calibration curve has been obtained, verification of the entire system may be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system (e.g., analyzer calibration, leaks, or HC hangup). A verification procedure is found in paragraph (e) of this section.

(c) *PDP calibration*. (1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the CVS pump.

(i) All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump.

(ii) The calculated flow rate, ft^3/min. (at a pump inlet absolute pressure and temperature), can then be plotted versus a correlation function which is the value of a specific combination of pump parameters.

(iii) The linear equation which relates the pump flow and the correlation function is then determined.

(iv) In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Two conditions must be maintained to assure the accuracy and integrity of the calibration curve:

(i) The temperature stability must be maintained during calibration. (Flowmeters are sensitive to inlet temperature oscillations; this can cause the data points to be scattered. Gradual changes in temperature are acceptable as long as they occur over a period of several minutes.)

(ii) All connections and ducting between the flowmeter and the CVS pump must be absolutely void of leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure N84–6. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following measurements and accuracies are required:

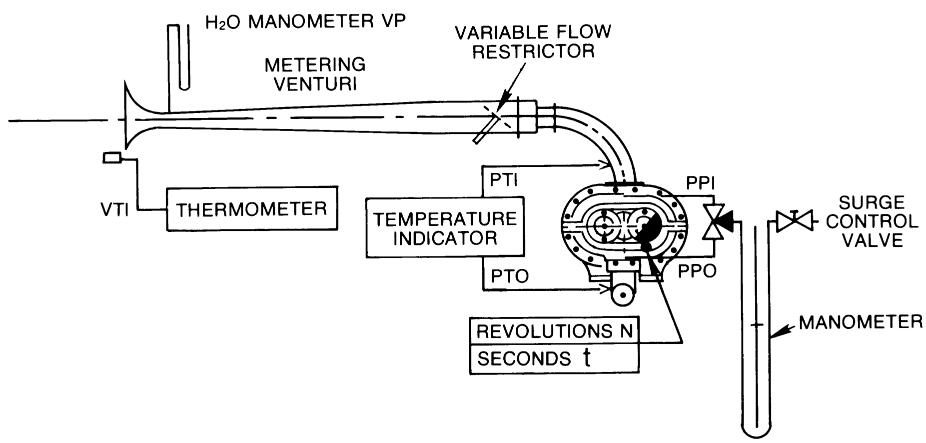

FIGURE N84-6 — PDP-CVS CALIBRATION CONFIGURATION

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Sensor-readout tolerances
Barometric pressure (corrected)	P_B	In. Hg (kPa)	±.10 in. Hg (±.340 kPa).
Ambient temperature	T_A	°F (°C)	±.5 °F (±.28 °C).
Air temperature into metering venturi	ETI	°F (°C)	±2.0 °F (±1.11 °C).
Pressure drop between the inlet and throat of metering venturi.	EDP	In. H2O (kPa)	±.05 in. H_2O (±.012 kPa).
Air flow	Q_S	Ft^3/min. (m^3/min.)	±.5% of NBS “true” value.
Air temperature at CVS pump inlet	PTI	°F (°C)	±2.0 °F (±1.11 °C).
Pressure depression at CVS pump inlet	PPI	In. Fluid (kPa)	±.13 in. Fluid (±.055 kPa).
Specific gravity of manometer fluid (1.75 oil)	Sp. G		
Pressure head at CVS pump outlet	PPO	In. Fluid (kPa)	±.13 in. Fluid (±.055 kPa).
Air temperature at CVS pump outlet (optional)	PTO	°F (°C)	±2.0 °F (±1.11 °C).

CALIBRATION DATA MEASUREMENTS—Continued

Parameter	Symbol	Units	Sensor-readout tolerances
Pump revolutions during test period	N	Revs	±1 Rev.
Elapsed time for test period	t	s	±.5 s.

(5) After the system has been connected as shown in Figure N84–6, set the variable restrictor in the wide open position and run the CVS pump for 20 minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) *Data analysis:* (i) The air flow rate, Q_s, at each test point is calculated in standard cubic feet per minute (68 °F, 29.92″ Hg) from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o, in cubic feet per revolution at absolute pump inlet temperature and pressure:

$$V_o = \frac{Q_s}{n} \times \frac{T_p}{528} \times \frac{29.92}{P_p}$$

Where:

V_o=Pump flow, ft³/revolution (m³/revolution) at T_p, P_p

Q_s=Meter air flow rate in standard cubic feet per minute, standard conditions are 68 °F, 29.92 inches Hg (20 °C, 101.3 kPa)

n=Pump speed in revolutions per minute

T_p=Pump inlet temperature °R(°K)
=PTI + 460 (°R), or
=PTI + 273 (°K)

P_p=Absolute pump inlet pressure, inches Hg (kPa)
$=P_B - PPI$ (Sp. Gr./13.5955) and
$=P_B - PPI$ for SI units

Where:

P_B=barometric pressure, inches Hg (kPa)

PPI=Pump inlet depression, inches fluid (kPa)

Sp. Gr.=Specific gravity of manometer fluid

(iii) The correlation function at each test point is then calculated from the calibration data.

$$x_o = \frac{1}{n}\sqrt{\frac{\Delta P}{P_e}}$$

Where:

X_o = correlation function.

ΔP = The pressure differential from pump inlet to pump outlet, inches Hg (kPa).
$= P_e - P_p$

P_e = Absolute pump outlet pressure, inches Hg (kPa)
$= P_B + PPO$(Sp. Gr./13.5955) and
$= P_B$ for SI units

Where:

PPO = Pressure head at pump outlet, inches fluid (kPa).

(iv) A linear least squares fit is performed to generate the calibration equation which has the form:

$$V_o = D_o - M(X_o)$$

D_o and M are the intercept and slope constants, respectively, describing the regression lines.

(8) A CVS system that has multiple speeds should be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o, will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ±0.50 percent of the measured value of V_o. Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model and range should agree within ±3 percent of each other. Particulate influx over time will cause the pump slip to decrease, as reflected by lower values for M. Calibrations should be performed at pump start-up and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(d) *CFV calibration.* (1) Calibration of the CFV is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

$$Q_s = \frac{K_v P}{\sqrt{T}}$$

The calibration procedure described in paragraph (d)(3) of this section establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_b	Inches Hg (kPa)	±.01 in Hg (±.034 kPa).
Air temperature, flowmeter	ETI	°F (°C)	±.25 °F (±.14 °C).
Pressure depression upstream of LFE	EPI	Inches H2O (kPa)	±.05 in H_2O (±.012 kPa).
Pressure drop across LFE matrix	EDP	Inches H2O (kPa)	±.005 in H_2O (±.001 kPa).
Air flow	Q_s	Ft³/min. (m³/min,)	±.5 pct.
CFV inlet depression	PPI	Inches fluid (kPa)	±.13 in fluid (±.055 kPa).
Temperature at venturi inlet	T_v	°F (°C)	±0.5 °F (±0.28 °C).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr		

(4) Set up equipment as shown in Figure N84–7 and eliminate leaks. (Leaks between the flow measuring devices and the critical flow venturi will seriously affect the accuracy of the calibration.)

(5) Set the variable flow restrictor to the open position, start the blower, and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least eight readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Qs, at each test point is calculated in standard cubic feet per minute from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

$$K_v = \frac{Q_s \sqrt{T_v}}{P_v}$$

(iii) Plot K_v as a function of venturi inlet pressure. For choked flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases. (See Figure N84–8.)

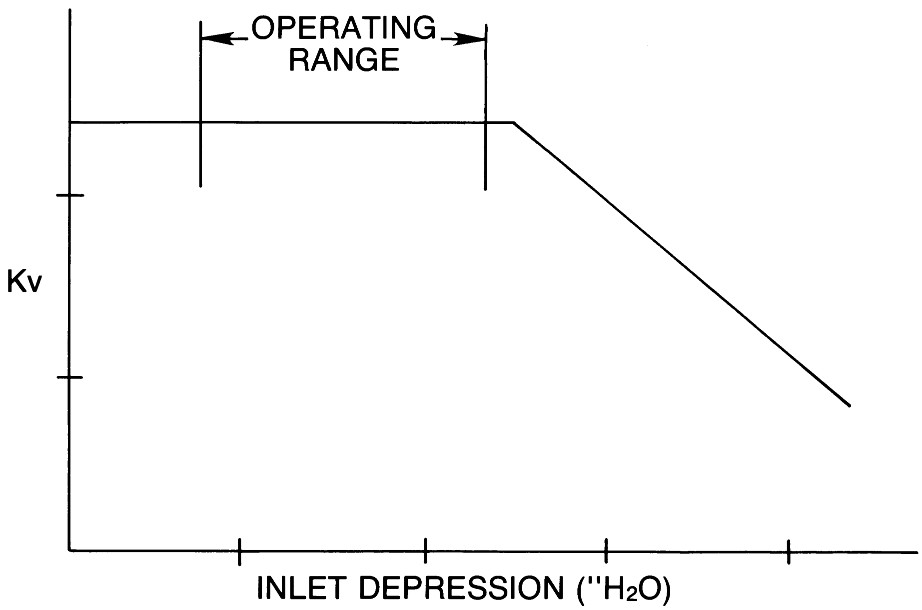

FIGURE N84-8— SONIC FLOW CHOKING

(iv) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3 percent of the average K_v, take corrective action.

(e) *CVS system verification.* The following "gravimetric" technique can be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane.

(2) Determine the weight of the reference propane cylinder to an accuracy of ±0.2 percent or less of the actual amount of propane discharged into the system.

(3) Operate the CVS in the normal manner and release a quantity of pure propane into the system during the sampling period (approximately 5 minutes).

(4) The calculations of §86.1342 are performed in the normal way except in the case of propane. The density of propane (17.30 g/ft^3/carbon atom (0.6109 kg/m^3/carbon atom)) is used in place of the density of exhaust hydrocarbons.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) Good engineering practice requires that the cause for any discrepancy greater than ± 2 percent must be found and corrected.

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48144, Dec. 10, 1984; 52 FR 47871, Dec. 16, 1987; 63 FR 24449, May 4, 1998]

§86.1319–90 CVS calibration.

(a) The CVS is calibrated using an accurate flowmeter and restrictor valve. The flowmeter calibration shall be traceable to the NBS, and will serve as the reference value (NBS "true" value) for the CVS calibration. (*Note:* In no case should an upstream screen or other restriction which can affect the